Rana hexadactyla Lesson owing to its more secretive nature and greater degree of camouflage-perfection eludes observation and capture. Both the species, however, never leave water.

114, Apollo Street,
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June 1, 1953.

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29. APOSEMATIC INSECTS AND THEIR FOOD PLANTS

Mr. Sevastopulo's comments (*J.B.N.H.S.*, 50, p. 951) on Mr. Winter-Blyth's remarks dealing with the possible interrelation between aposematic insects and their food plants interested me greatly, and called to mind some observations made in the field some years ago. At the time, I speculated on the possibility of the food plants imparting the protective odours emitted by such insects, but did not commit my observations to paper. I saw no valid reason why the offensive or otherwise noxious properties of the food plants should not be reflected by the individuals feeding on them. How often has it been noted that edible water-fowl when feeding on certain aquatic vegetation are distasteful, which, at other times are delicious? This is particularly true of wild duck.

Some years ago a note was published in the *Journal* describing the 'poisonous' effect on humans who had eaten fish which in their turn had fed on the fruit of the *Kalaw* (*Taraktogenos* sp.). The fish acquire the poisonous qualities only at the time when they feed on the *kalaw* fruit, and are perfectly wholesome at other seasons. Here we have an instance of the food imparting its poisonous qualities to the flesh of the fish without otherwise affecting the fish in the least. Similarly I think it is well-known that the body odours of mankind (apart from the deliberate application of external scents) very often reflect the diet of a particular individual or community. For example, garlic (*Allium ursinum*) or *methi* (*Trigonella foenumgraecum*) if eaten regularly is 'sweated out' and gives a distinctive body odour. Some other edible substances produce the same result. Similarly, people who consume much vegetable oil 'exude' the oil, and the skin looks 'oily'. From such examples it seems clear that the food plays an important part in producing particular odours. Perhaps during the process of digestion some of the odoriferous substances become more concentrated and are exuded through the skin. The constitution of aposematic insects possibly have special means of concentrating these substances and using them to advantage by storing them in special organs or cells. However, here I must leave generalizations and turn to specific instances.

Aularches miliaris : The colouration of this grasshopper is well-known and therefore needs no description. The nymphs of the species display more black and red ; the green and yellow markings, are absent. The nymphs, like the adults are gregarious, but more so. They collect

in large numbers ranging from fifty to a couple of hundred. Such gatherings may be seen sitting on the leaves of *Heterophragma roxburghi* during the hot and dry weather. They sit on the upper surface of the leaves in full view, but if alarmed they drop to earth and seek shelter on the forest floor. Incidentally *Heterophragma* is perhaps an exceptional tree in the deciduous forests in so much that it is the only tree which is in full leaf when others are leafless, and leafless during the monsoon when all other trees are in full foliage! The black, naked trunks and branches stand out remarkably during the rains, just as the 'silvery' stems of *Sterculia urens* stand out during the hot weather.

The crushed leaves of *Heterophragma*, as well as the flowers and fruit emit a pungent, offensive odour. The nymphs of *Aularches* feed on the leaves of this plant and emit a similar odour when handled. I do not know what the natural enemies of this grasshopper are but it certainly enjoys a certain amount of immunity from predators. Incidentally, *Heterophragma* itself is seldom attacked by insects, but the leaves are subjected to a brown rust.

During the monsoon the adults of *Aularches* feed mainly on the foliage of *Gloriosa superba*. In some years these grasshoppers appear in greater numbers than usual and in consequence extensive damage is done to *Gloriosa*. Whole patches of the plant are defoliated. *Gloriosa* is known to be highly poisonous and the crushed leaves give off a strong acrid odour. The grasshopper, as though 'aware' of its warning colours and its defensive noxious odour, sits in the open and is not easily disturbed; at most, it will 'kick off' into another portion of the bush, and will make no attempt to hide. Although provided with strong wings it is seldom seen in flight. When caught it emits a frothy mass at the base of the jumping legs, at the same time vomiting a blackish liquid, in the same way as many other grasshoppers do under the same circumstances. The smell of the foam is very acrid and reminiscent of the crushed leaves of *Gloriosa* but in more concentrated form. The odour of the vomit is similar but not so volatile. The smell is so strong that the air is permeated with it. As in the case of *Heterophragma, Gloriosa* enjoys a fair share of immunity from insect pests.

The interesting part of *Aularches* is that the nymphs and adults feed on different plants and both reflect the odour of the particular species they predominantly feed upon.

Poecilocerus pictus F.: *Poecilocerus* is another grasshopper remarkable for its brilliant colouring. It is always associated with the two species of *Calotropis* (*procera* and *gigantea*). It is more commonly found in the drier areas on *C. procera* than in the wetter regions. I am not familiar with the early hopper stages, but as far as I am aware the insect does not feed on any other asclepiad. Although the animal is brilliantly coloured, the colouring is slightly masked by a soft 'bloom' resembling the bloom found on the plants themselves. It is somewhat heavily built and sluggish of habit—reluctant to move. When disturbed its first attempt to evade the intruder is to move round to the opposite side of the branch. On the whole it is less sportive

than *Aularches* and less gregarious, one or two being the usual number on each plant. When handled it emits an odour similar to the bruised leaves of *Calotropis* at the same time vomiting a pungent smelling liquid. As far as I can remember this species does not produce the foam at the base of the legs as does *Aularches*.

LEPIDOPTERA: Among the butterflies and moths there are numerous examples exhibiting aposematic colouration coupled with noxious odours, the odours resembling the crushed parts of the food plants. For example, *Danais chrysippus* reflects the odours of the various asclepiads upon which it feeds. *Danais limniace* larvae feed on the leaves of *Crotolaria* (*retusa*?) and the butterflies themselves collect in vast numbers on the same plants, sometime accompanied by *Euploea core*. *Limniace* has an odour resembling the *Crotolaria*. Many other examples could be quoted, but as some have already been referred to by other authors I shall not labour the subject.

HEMIPTERA: Among the so-called garden- or mother-bugs there are some marked examples exhibiting the similarity of odour between the food plants and the animals themselves. Some go still further by ejecting a smelly fluid. This fluid, should it reach the eye or other mucous membrane, may cause a certain amount of smarting as I have experienced to my cost when out insect collecting at night! Nevertheless, there are some which emit quite a different odour to that of the food plant. I am not attempting an explanation of this phenomenon! In spite of the warning colours and disagreeable odours and perhaps taste (to most birds) the cuckoos feed largely on bugs.

COLEOPTERA: Among the beetles there are also numerous examples showing similar and dissimilar odours to the food plants. To take a single example, the flea-beetle, *Haltica*, feeds largely on *Ammania* and emits the same odour as the plants. That these beetles appear in such large numbers as they do each season seems to indicate that apart from their colouring and their habit of 'kicking off' when alarmed (as many Chrysomelidae do), they appear to enjoy immunity from would-be enemies on account of the odour they emit.

There seems to be little doubt that the odours which protect many insects from would-be enemies are derived directly from the chemical properties contained in the food plants, some of which may be elaborated into other offensive substances during the process of digestion. The change of food plant seems to occasion a change of odour as in the case of *Aularches*. However, there is much to learn of the life-cycle of many of the commoner aposematic insects which might throw some light on the subject, and a careful biochemical analysis of both insect and food plants may produce some interesting results.

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